2. This concentration of denuding agencies has worn down the peaks and passes and the plateau regions along this course to the maximum extent, thus causing their slow and constant upheaval, and a corresponding depression of remote areas to which the sediments have been borne.

3. This denudation has also caused maximum exposures of the oldest formations along this path.

The traces of cyclonic activity are thus marked both physically and geologically across the continent.

DETERMINING ATMOSPHERIC CONDITIONS OF COMFORT

By FRANK M. PHILLIPS, Ph. D.

[George Washington University, Washington, D. C., December 7, 1924]

Much is being written in the various scientific journals and books on optimum conditions of heat and humidity for human beings engaged in different activities. The attempt, apparently, is to determine conditions of comfort. The question at stake is not so much what atmospheric conditions are most bracing, nor what give the body most resistance, nor what points on the thermometric and the barometric scales are conducive to health, but what conditions give the least discomfort, which may be one and the same thing as optimum conditions for health.

The New South Wales factory act[1] requires a mean dew point of 62° F., and allows a variation of only 5° either way.

The writer has devised the accompanying chart showing several scales for atmospheric conditions. The horizontal scale is for dry-bulb readings, the vertical one for wet-bulb readings. The solid curves running diagonally across the chart give the relative humidity readings, and the dotted lines give the corresponding dew-point scale. The psychrometric readings can thus be converted into relative humidity and dew-point readings at a glance.

[1] Purdy, J. S.: Lighting and Ventilation of Factories. *The Journal of Industrial Hygiene*, March, 1922, pp. 349-358.

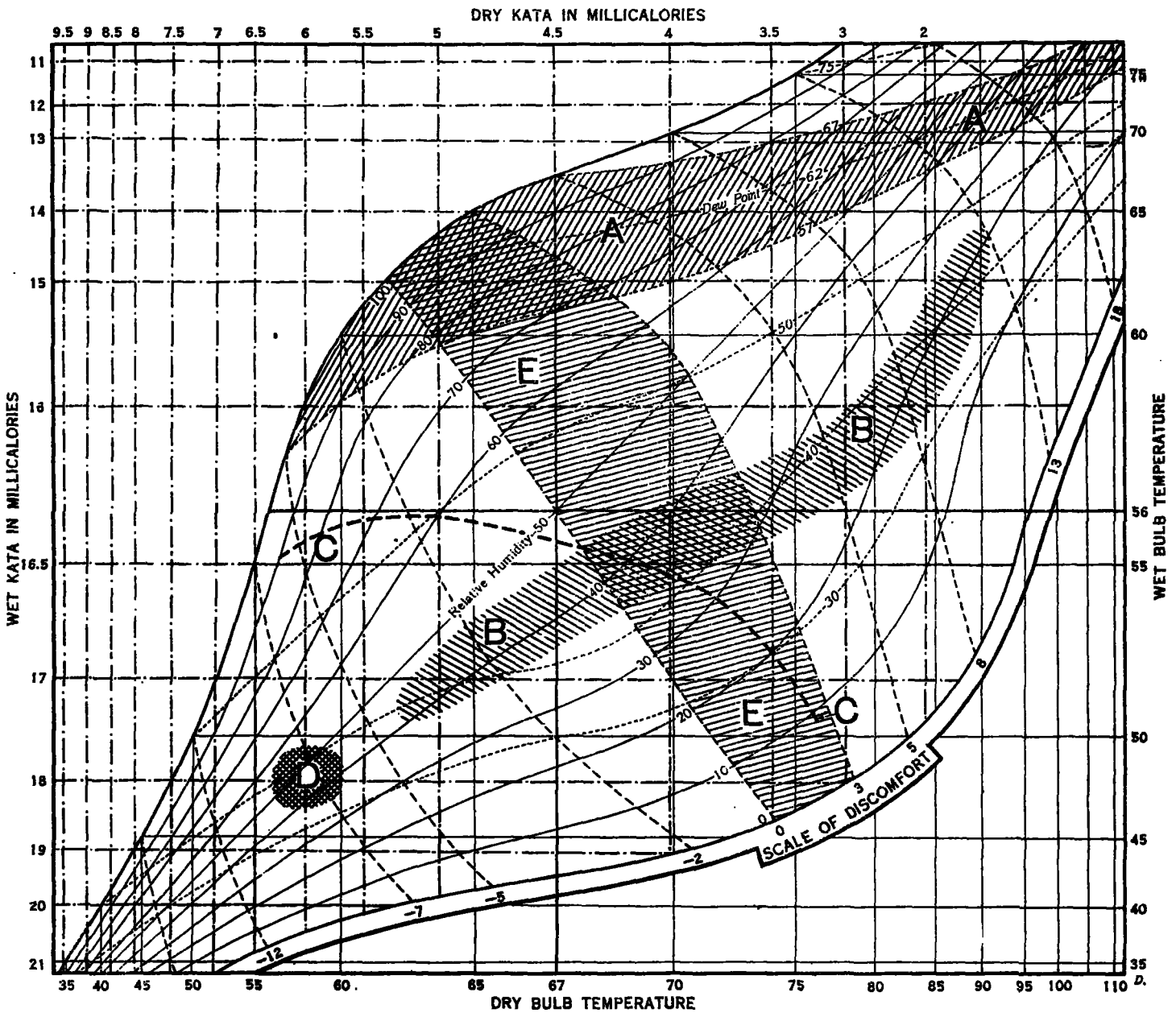

FIGURE 1.

The shaded portion of this chart marked AA shows the comfort area as embodied into the New South Wales law. This law, apparently, does not permit much deviation from these dew-point readings, and does not limit air movement as a function of cooling, although it must be recognized that velocity of air is an important point in furnishing comfort.

It is also evident that the employees require higher temperatures for light sedentary work, than they do for heavy work in which much muscular exertion is necessary.

According to Pierce,[2] the air conditions may vary from 63° F. with a humidity of 40 per cent to 90° F. with a humidity of 25 per cent, and still give comfort in the home. This area is marked BB in the chart. Air movement is again omitted from consideration, but race types are mentioned. These conditions are given as optimum for the home and the hospital, but the author shows the impossibility of hard work in conditions outside of the marked comfort area.

If the comfort area, between certain temperature limits, is determined by the formula used by some heating and ventilating engineers, it is that portion marked CC on the chart. The formula is, $R = 316 - 4$ F.—that is, the conditions most favorable are such that the relative humidity in per cent, should be 316 minus four times the dry bulb reading in F. degrees. Air movement is not considered.

The work of Hill [3] has done more, perhaps, to initiate a scientific study of optimum atmospheric conditions than any other report. A number of interesting articles[4] have appeared.

In most of these articles the principle of the kata thermometer is used. The dry kata cools by radiation and by convection, the wet kata by these and by evaporation in addition. The most satisfactory condition as agreed upon by Hill and his followers in kata readings are here given: For sedentary work a dry kata reading of 6 millicalories and a wet kata reading of 18. For light manual work the readings should be 8 and 25, and for heavy manual work, 10 and 30, respectively. The chart has a wet kata scale in horizontal dots and dashes, and a dry kata scale in vertical dots and dashes. The 6 to 18 area is designated by D.

These instruments, especially the wet kata, are affected by air currents, so that temperature, humidity, and air velocity all function in the results.

The human body, however, is perhaps never a dry kata as far as its surface is concerned, and seldom, if ever, does it become exactly comparable to a wet kata. The use of these instruments, however, has opened up new methods of dealing with questions concerning problems of heating and ventilation.

As one views the accompanying chart, he wonders why these areas, determined as they are to locate comfort areas, should be so far apart. Do the investigators find different answers to the same question? Do the physiologists disagree upon what constitutes comfort? Do racial differences, or geographical locations, cause what is comfort for one set of persons to be discomfort for another set, brought up to live under different climatic conditions?

There remains one more area to notice. Experiments in the laboratories of the Bureau of Mines in Pittsburgh, as shown by investigators from the American Society of Heating and Ventilating Engineers [5] seem to determine comfort lines by making use of bodily sensations of several subjects, and verified by physiological measurements. These lines of equal comfort are shown in the chart by dashed lines. The experiments show the 64° effective temperature line as most comfortable for the light activities in still air. The area is marked EE. Lines for different kinds of work, and for air in motion have yet to be determined.

This area, EE, corresponds only in part with the other four areas determined by different investigators and in different ways. The methods used in determining this last area seem to be purely scientific and accurate, and if pursued to the limit ought to answer some of the questions proposed earlier in this article. Such an experiment involves the use of many subjects of different race stocks, different ages, and different geographical residences, but in time should definitely answer the problem of maximum comfort and degrees of discomfort.

[2] Pierce, W. Dwight. *The Nation's Health*, September, 1922, pp 463–566.

[3] Hill, L.: The Science of Ventilation and Open Air Treatment. *Part II, Medical Research Council, Special Report, Series No. 52*. London, 1920.

[4] Orenstein and Ireland: Experimental Observations upon the Relation of Atmospheric Conditions and the Production of Fatigue in Mine Laborers. *The Journal of Industrial Hygiene*, May, 1922, pp. 30 et seq., followed by a continuation in the June number, pp. 70 et seq.

Vernon, H. M.: Recent Investigations on Atmospheric Conditions in Industry. *The Journal of Industrial Hygiene*, December, 1922, pp. 315–324.

Eadie, Ash, and Angus: Observations of the Reliability of the Comf-thermometer as an Indicator for the Cooling Effect of the Air. *The Journal of Industrial Hygiene*, February, 1923, pp. 441–447.

Hill, Vernon, and Ash: The Kata Thermometer as a Measure of Ventilation. *Proc. Royal Society*, 1922, 93B, 198.

Sayres and Harrington: A Preliminary Study of the Physiological Effects of High Temperatures and High Humidities in Metal Mines, *Engin. and Mining Journal*, 1920, pp. 110, 401.

[5] Houghten and Yagloglou: *Journal of the Society of Heating and Ventilating Engineers*, 1923.

Houghten and Yagloglou: Determination of the Comfort Zone, semiannual meeting of the Society of Heating and Ventilating Engineers, Chicago, May 21–23, 1923, pp. 29–45.

McConnell, Phillips, and Houghten: The Physiological Effects of High Temperatures and Humidities in Still Air. *Public Health Reports*. (In press.)

623.451.8

THE HIGH-ALTITUDE ROCKET

By R. H. GODDARD, Director Physical Laboratories

[Clark University, Worcester, Mass.]

A recent request by the editor of the MONTHLY WEATHER REVIEW for a statement on the rocket development gives a welcome opportunity to present first hand the aims and results of the investigation.

The work at present being carried on is the development of a small model which will have a sufficient vertical range to demonstrate clearly the correctness of the principles that are involved. The propellant consists of liquids, first suggested publicly in 1914, and tested experimentally in 1921, it having been found possible in this way to obtain propulsive force without excessive heating.

After a satisfactory demonstration of this model has been made, the next step, which, it is hoped, will be sufficiently supported financially, is the exploration of the atmosphere in the wide unknown region extending upward from 30 km. to 750 km. (20 to 460 miles). Among the interesting matters to be investigated in this region are whether or not the conclusions from meteoric studies are correct, that the upper limit of the stratosphere is at 60 km. (37 miles), where the temperature rises from $-53°$ C. to 27° C., in a region of ozone, or the conclusions from auroral studies are correct, that the upper limit is at 90 km. (56 miles), where the temperature falls, there being a region above consisting largely of nitrogen at a temperature below 60° A., and extending upward for hundreds of kilometers. In this connection it should be stated that Prof. W. J. Humphreys, of the United States Weather Bureau, has suggested a very simple and clever means of carrying out the most difficult of the measurements, namely, that of temperature.